



L5 Signal Characteristics

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Topics

- **L5 Signal Design Status**
- **Characteristics Summary**
- **PN Code Structure and Properties**
- **Signal Modulation**
- **Data Structure**
- **Data Content**

L5 Signal Design Status

- **Signal design is complete**
- **RTCA SC159 is publishing an L5 Signal Specification**
 - **Version 1 will be mailed to committee members this week for review**
 - **Some specification details affected by SV design are replaced with comments**
 - Phase Noise specification
 - Correlation Loss specification
 - Detailed Received Power specification

Specification Details Affected by SV Design

- Changes are also being proposed for SPS Specification
- Prefer that signal characteristics be given rather than general effects
 - Bandwidth, antenna pattern, EIRP, phase noise spectral density
 - Let diversified users evaluate based upon application

Characteristics Summary

- **L5 = 1176.45 MHz**
- **Allocated BW = 24 MHz (anticipated)**
- **Minimum Received Power = -154 dBW**
- **PN Code Chipping Rate = 10.23 MHz**
- **QPSK Signal**
 - **In-Phase (I) = Data Channel**
 - **Quadraphase (Q) = Data-Free Channel**
 - **Equal Power in I and Q (-157 dBW)**
 - **Independent PN Codes on I and Q**

Characteristics Summary (Cont.)

- **I and Q Modulation (1 kbps)**
 - FEC encoded 50 bps data on I (100 sps)
 - Further encoded with 10-bit Neuman-Hoffman Code
 - Q encoded with 20-bit Neuman-Hoffman Code
 - More details to follow

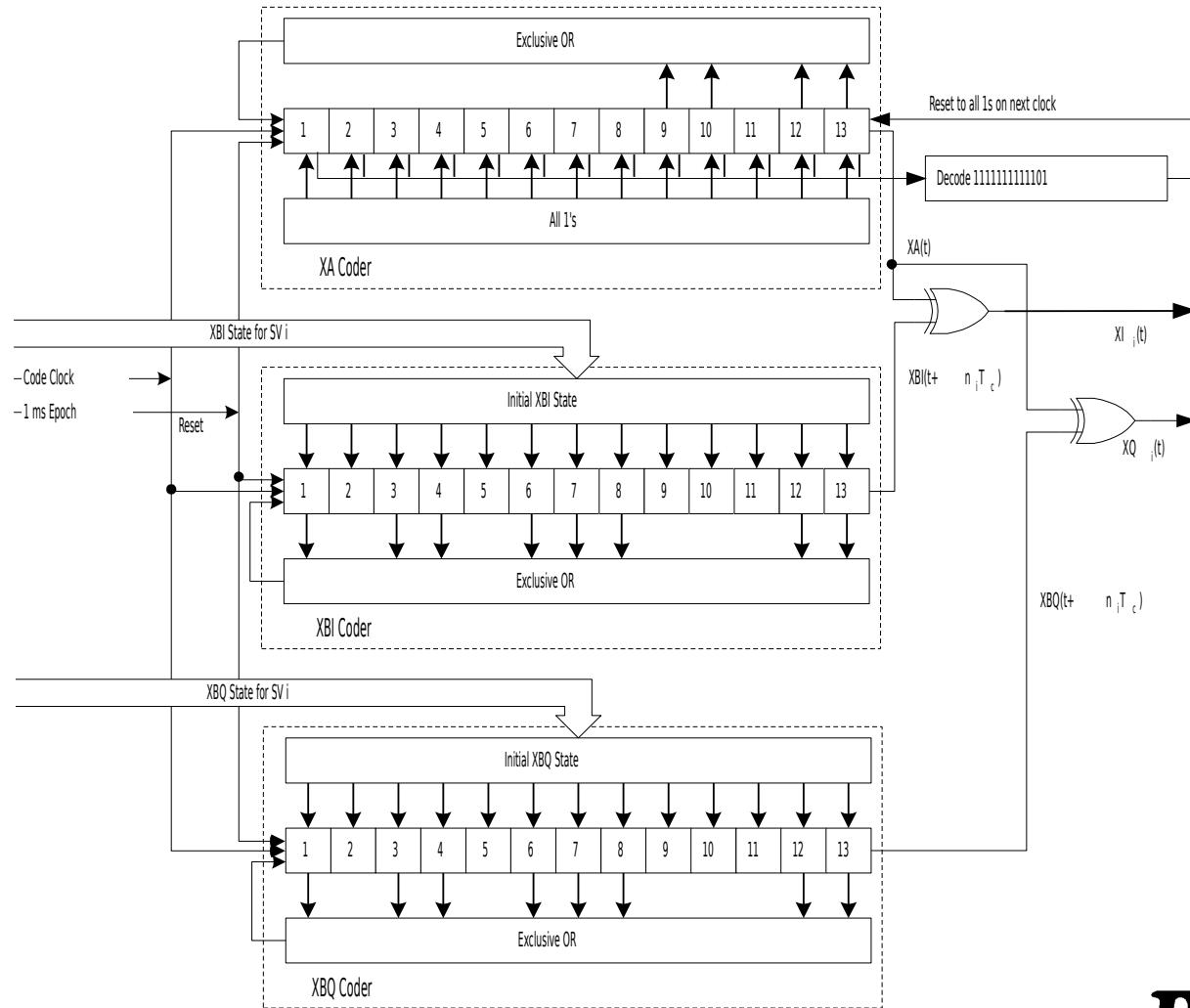
L5 Codes and Code Properties



L5 Codes

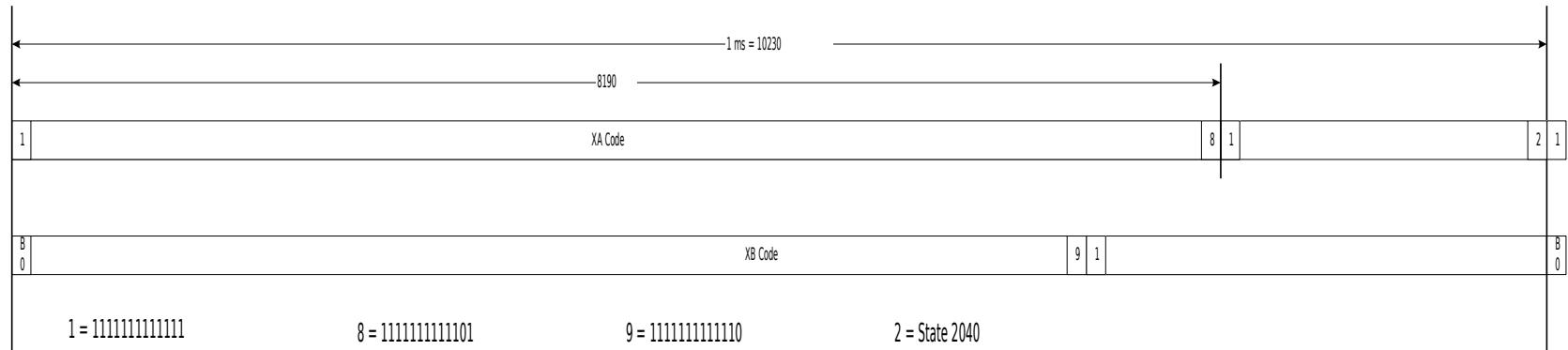
- **Codes with 2 - 13 stage shift registers**
 - Length of one (XA code) = 8190 chips
 - Length of second (XB code) = 8191 chips
 - Exclusive-Or'd together to generate longer code
- **Chipping rate of 10.23 MHz**
 - Reset with 1 ms epochs (10,230 chips)
- **Two codes per satellite (4096 available)**
 - One for Data channel, one for Data-Free channel

L5 I & Q Code Generators

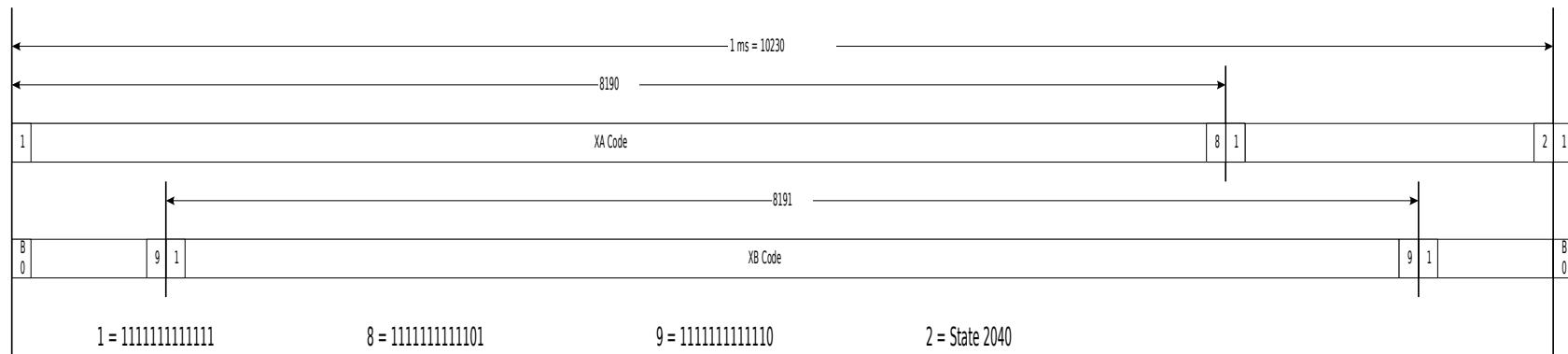


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L5 Code Generator Timing



a) B0 = Initial State at 1 ms (less than State 6152)



b) B0 = Initial State at 1 ms (greater than State 6151)

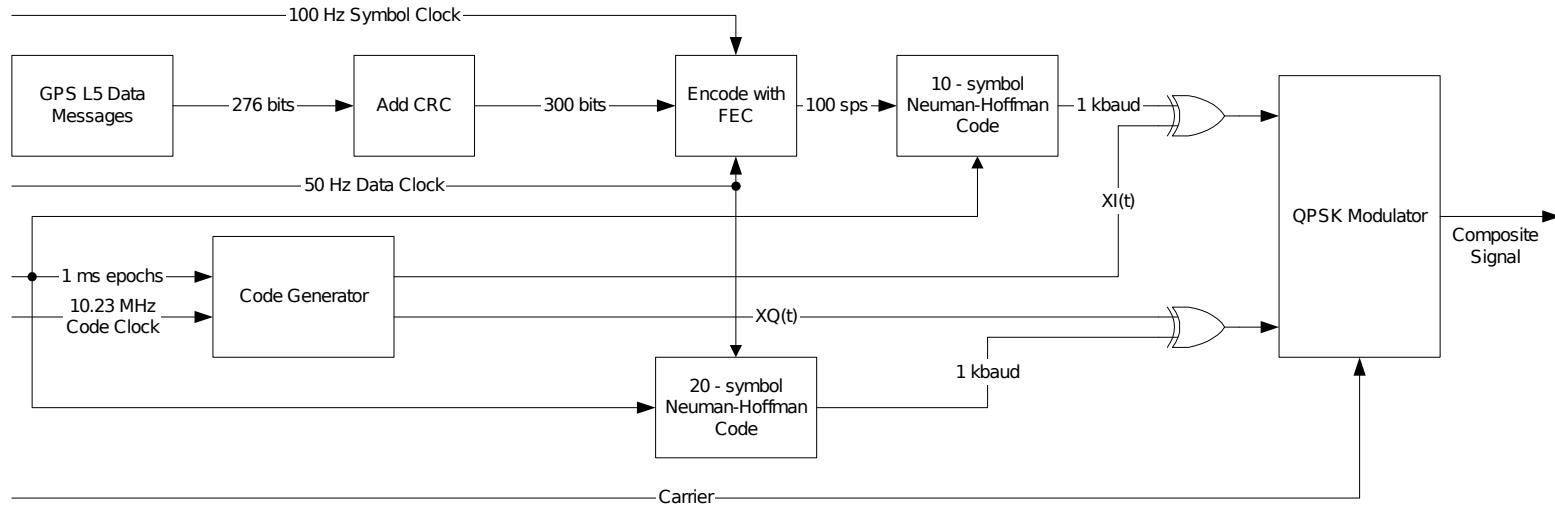
L5 Code Performance Summary

- **74 Codes have been selected**
 - 37 I, Q pairs
- **Maximum non-peak autocorrelation ≈ -30 dB**
- **Maximum cross-correlation with other selected codes ≈ -27 dB**
- **Average autocorrelation and cross-correlation ≈ -42 dB**
- **Maximum cross-correlation between I, Q pairs < -74.2 dB**
- **Another pair selected as non-standard code**

L5 Signal Modulation

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L5 I & Q Code and Symbol Modulation

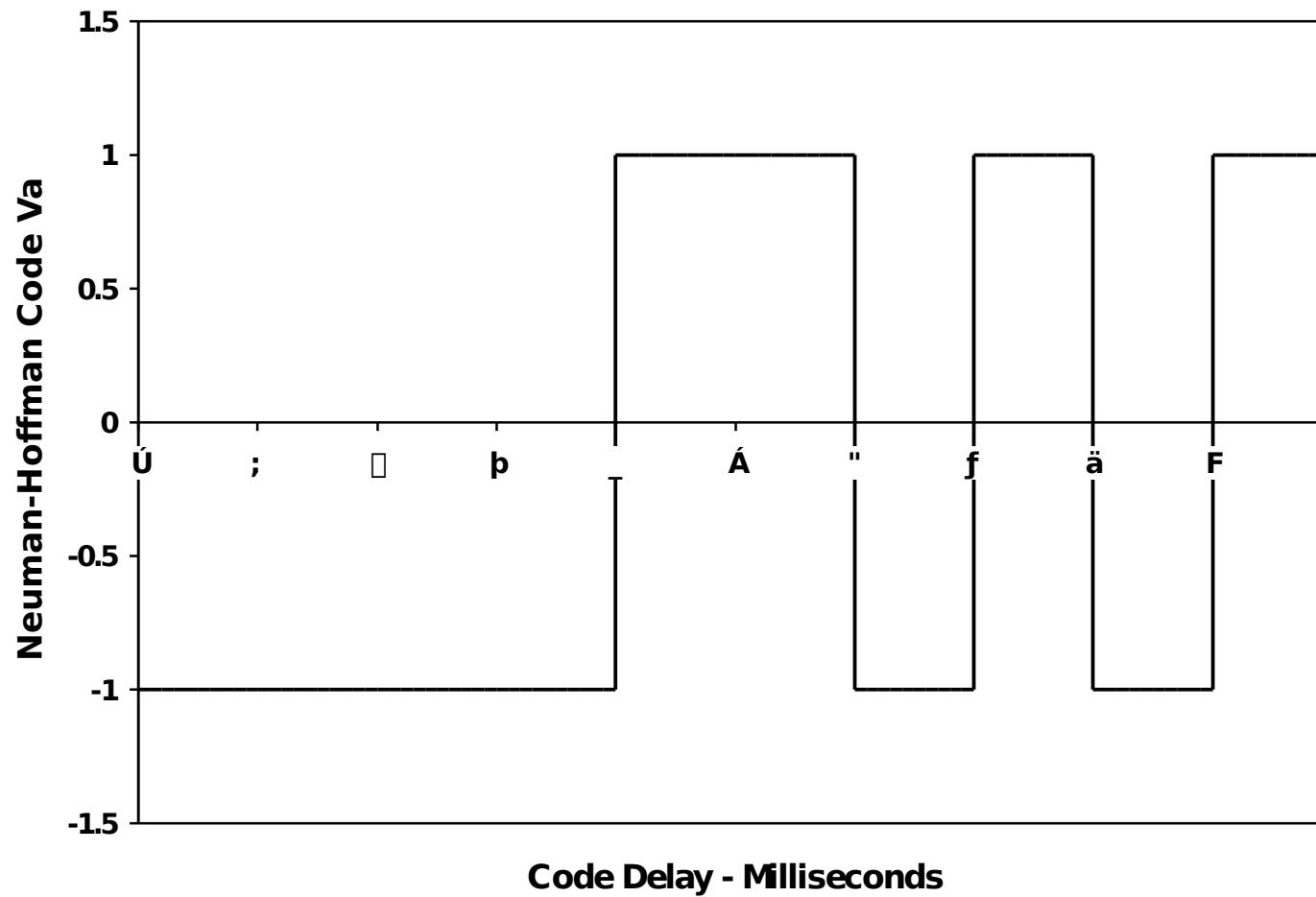


- **(Coded) coherent carrier in-quadrature with data**
 - Allows for robust code & carrier tracking with narrow pre-detection bandwidth
 - Independent codes to remove QPSK tracking bias

Neuman-Hoffman Codes

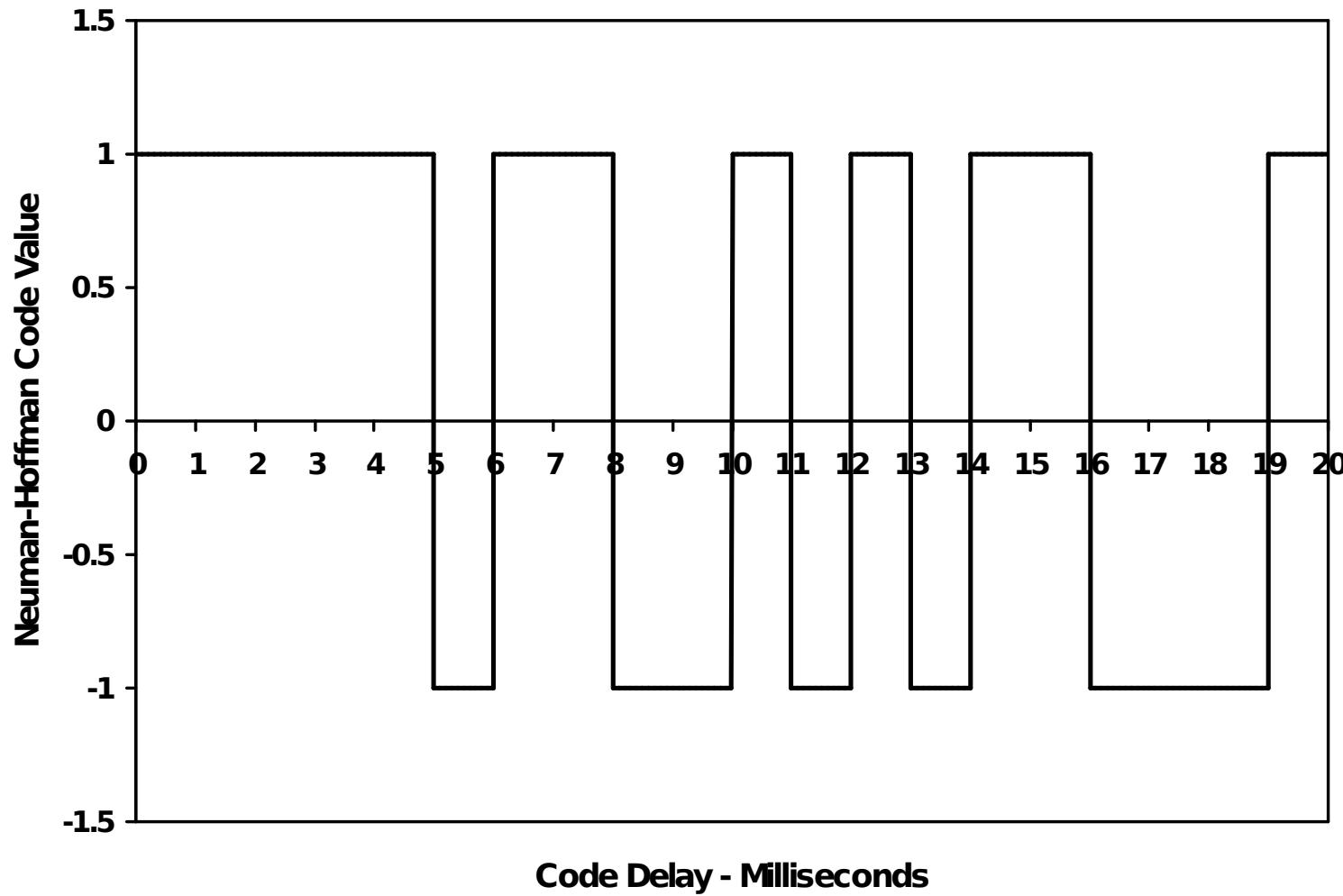
- **Encoded symbols and carrier**
 - Modulated at PN Code epoch rate
 - Spreads PN Code 1 kHz spectral lines to 50 Hz spectral lines (including FEC)
 - Reduces effect of narrowband interference by 13 dB
 - Primary purpose of NH Codes
 - Also allows detection of narrowband interference
 - Reduces SV cross-correlation most of the time
 - Provides more robust symbol/bit synchronization

10-ms Neuman-Hoffman Code on I



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20-ms Neuman-Hoffman Code on Q



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L5 Data Content & Format

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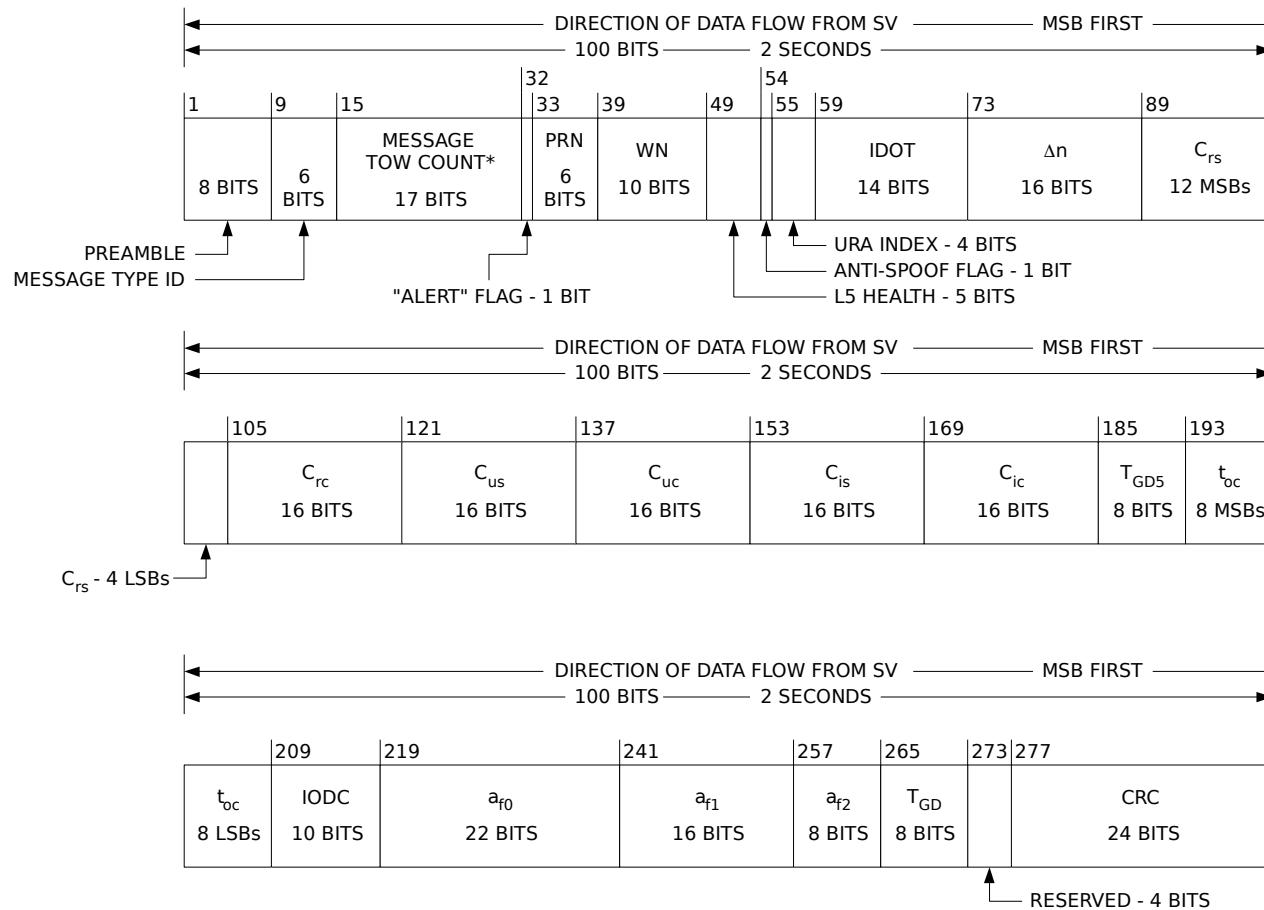
L5 Data Content & Format

- **5 - Six-Second 300-bit Messages**
 - Formated with 24-bit CRC (same as WAAS)
 - Encoded with Rate 1/2 FEC
 - To make up for 3-dB QPSK reduction
 - Symbols modulated with 10-bit Neuman-Hoffman Code
- **Messages scheduled for optimum receiver performance**
- **Lined up with L1 sub-frame epochs**

L5 Message Types (of 64 possible)

- **Message Type 1 - Ephemeris/Clock I**
- **Message Type 2 - Ephemeris/Clock II**
- **Message Type 3 - Ionosphere/UTC**
- **Message Type 4 - Almanac**
- **Message Type 5 - Text Message**
- **Anticipated that Ephemeris/Clock Messages would be repeated every 18-24 seconds**

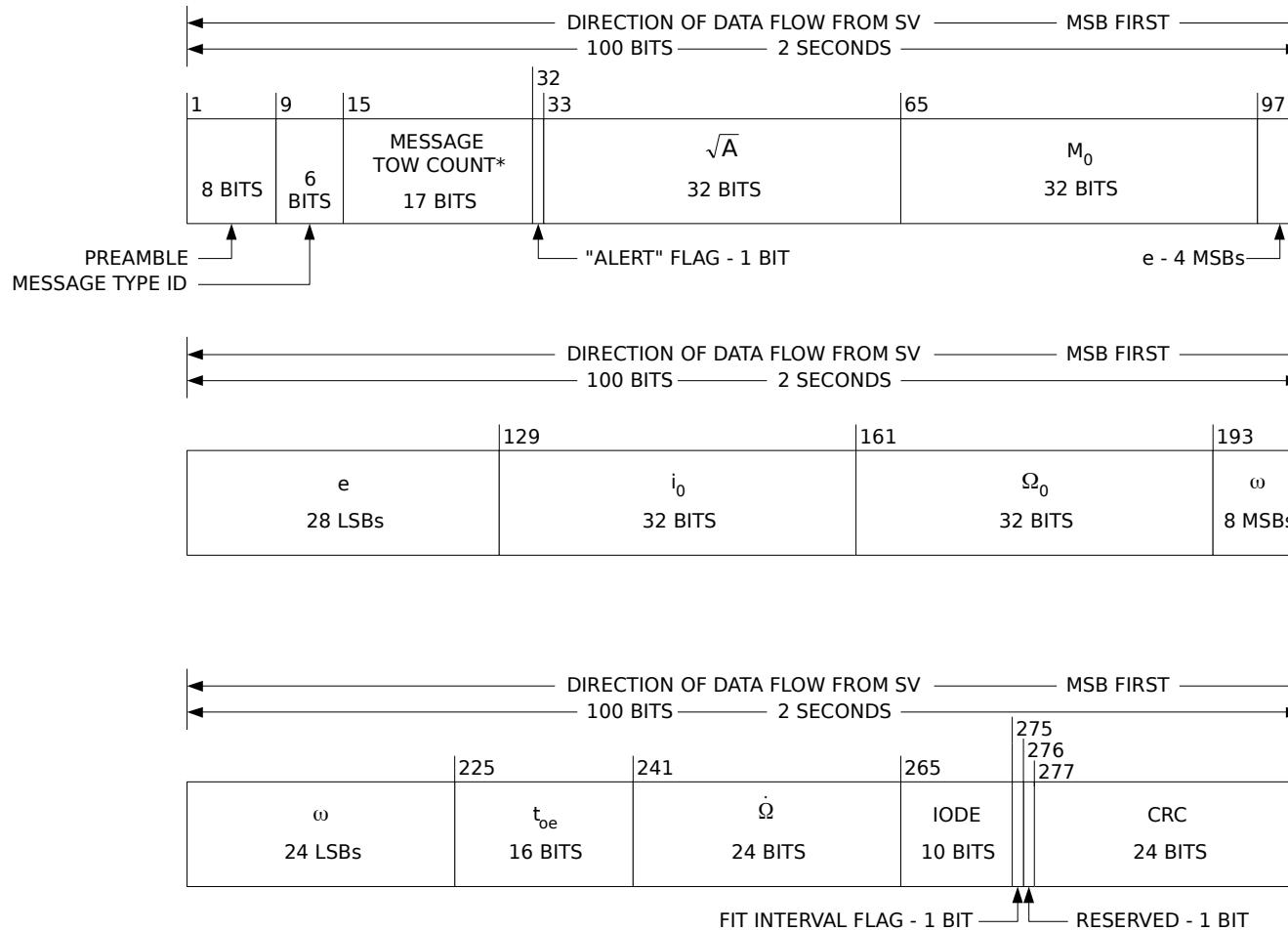
Message Type 1



* MESSAGE TOW COUNT = 17 MSBs OF ACTUAL TOW COUNT AT START OF NEXT 6-SECOND MESSAGE

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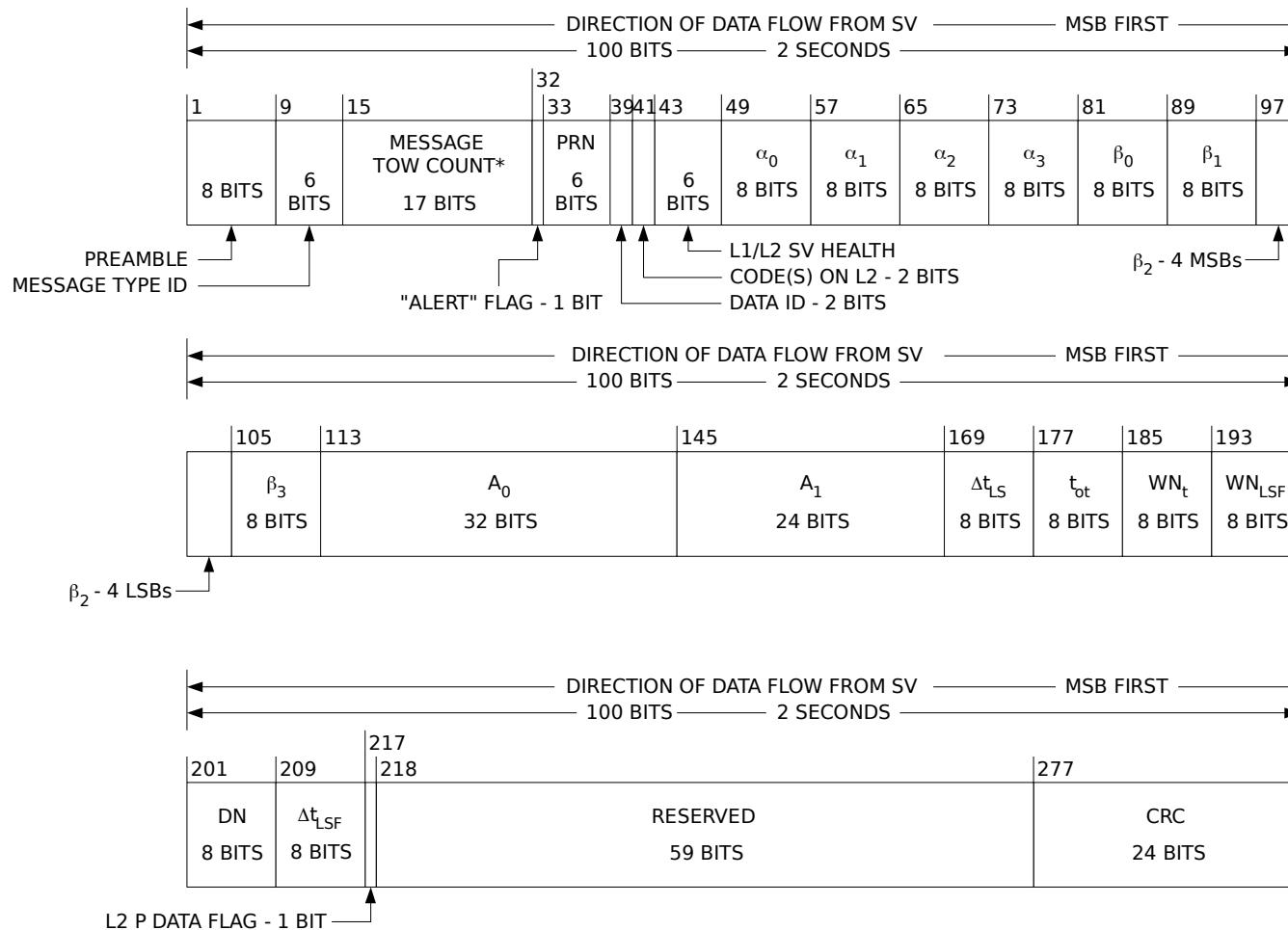
Message Type 2



* MESSAGE TOW COUNT = 17 MSBs OF ACTUAL TOW COUNT AT START OF NEXT 6-SECOND MESSAGE

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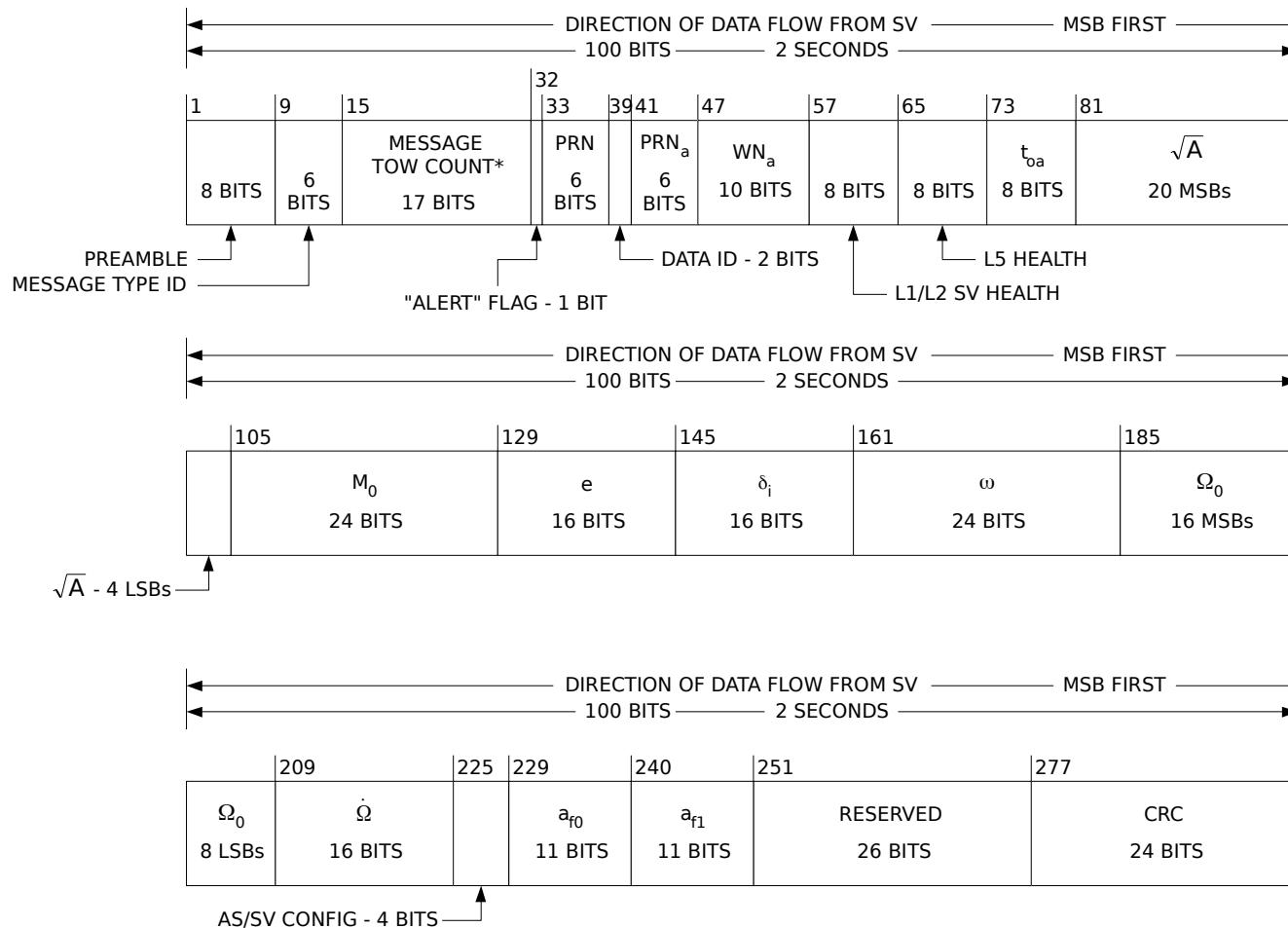
Message Type 3



* MESSAGE TOW COUNT = 17 MSBs OF ACTUAL TOW COUNT AT START OF NEXT 6-SECOND MESSAGE

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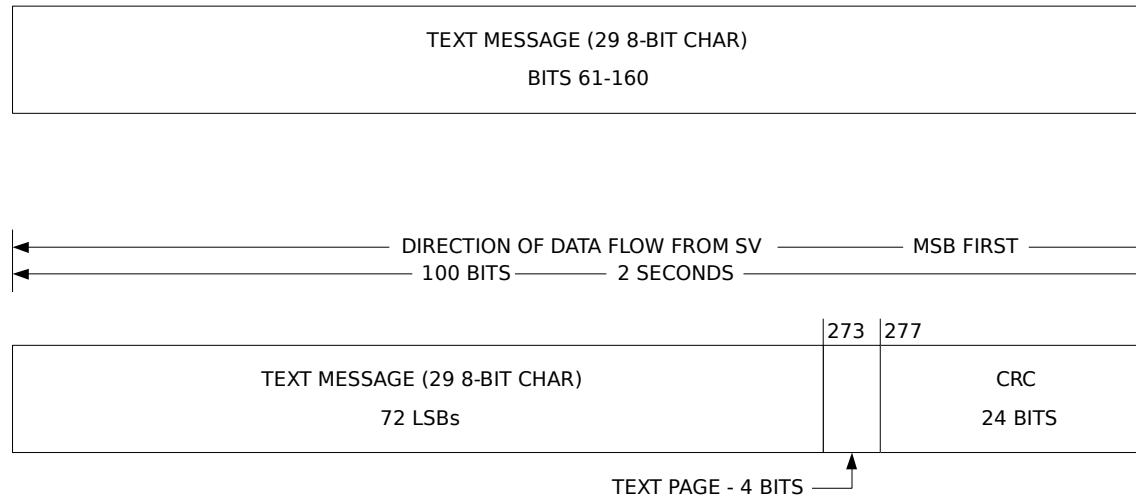
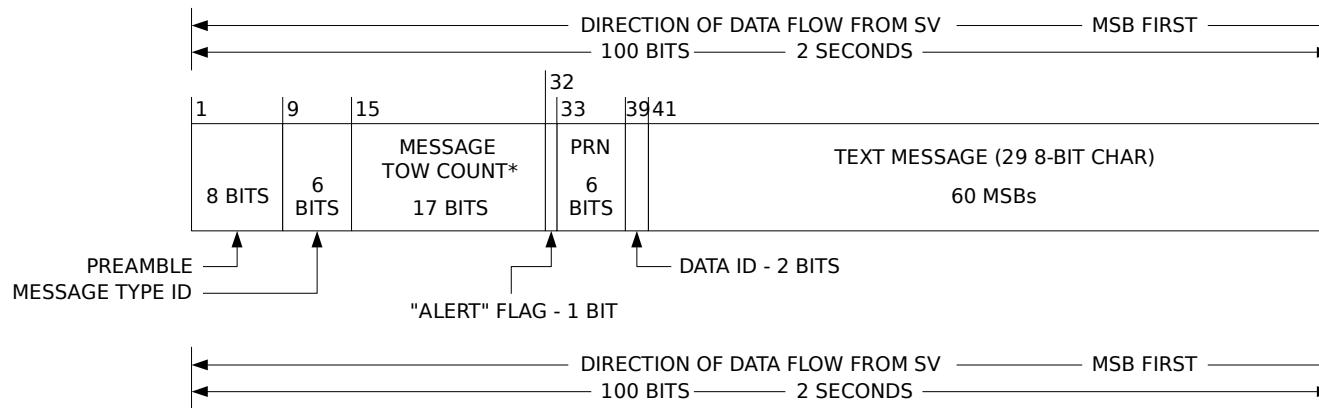
Message Type 4



* MESSAGE TOW COUNT = 17 MSBs OF ACTUAL TOW COUNT AT START OF NEXT 6-SECOND MESSAGE

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Message Type 5



* MESSAGE TOW COUNT = 17 MSBs OF ACTUAL TOW COUNT AT START OF NEXT 6-SECOND MESSAGE

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Message Content

- **Mostly, content is same as on L1**
- **Add L5 Group Delay variable**
- **Add L5 Health**
- **Different Text Message**
- **Add PRN number**
- **Peculiar L5 information can be provided by civil community**

GPS III Considerations

- **Higher data rate to include integrity data for safety-of-life service**
 - Promised by Galileo
- **Second real-time uplink for and operated by safety-of-life service**
 - To meet integrity and time-to-alarm requirements

Special Acknowledgements

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